9.—Sea Temperatures on the coast of South Western Australia

by E. P. Hodgkin* and B. F. Phillips*†

Manuscript received 22 October 1968; accepted 18 February 1969

Abstract

Surface water temperatures in Cockburn Sound, near Fremantle, are shown to follow the same seasonal cycle as air temperatures, but with a smaller range. The highest monthly mean temperature recorded was 24.7°C and the lowest was 12.8°C. Offshore water temperatures show a marked lag as compared with inshore temperatures and the annual range is smaller than either Cockburn Sound or near Fremantle. Water temperatures at Geraldton show the same pattern as in Cockburn Sound, but a slightly smaller range, and the mean is about 2°C higher.

Introduction

Ecological studies of marine animals are continually hampered by the lack of appropriate environmental data, normally available to workers in terrestrial situations. Of the measurable factors in the marine environment temperature is perhaps the most universally used. Its selection is, however, based not only upon ease of recording but upon established relationships between temperature and breeding, rate of growth, mortality and behaviour in many different species.

Sea water temperatures have been recorded by ships entering and leaving the Port of Fremantle for many years and have been taken by a number of special agencies, nevertheless they do not appear to have been collated and published in a form convenient to biologists. Charts published by the Royal Netherlands Meteorological Institute (1949), G.B. Meteorological Office (1949), and U.S. Navy, Hydrographic Office (1944) show ocean temperatures, month by month, as area means. Enormously valuable as these are, the very fact that they are mean values, and for the open ocean, limits their value to anyone interested in actual temperatures close to the coast.

Temperatures recorded

Since the establishment of the BP Oil refinery at Kwinana in Cockburn Sound, the maximum and minimum temperature of the cooling water has been taken daily at the intake. The daily mean temperatures have kindly been made available to us by the refinery management for the eight years 1960-67.

These temperatures then are those of surface water close to the shore in Cockburn Sound. They are summarised in Table 1. The 1960 and 1967 figures are shown in Figure 1, in which air temperatures recorded at the Perth Observatory during these years are also included.

Water temperatures at stations in Gage Roads and off Rottnest Island were recorded between 1949 and 1956 and these are published in the C.S.I.R.O., Division of Fisheries and Oceanography Station Lists Nos. 3, 14, 18, 24, 27 and 30. No recordings were made in these areas during the period 1960-67. The figures for 1953 are shown in Figure 2.

Surface water figures have been recorded weekly since 1966, in the harbour at Geraldton (at 1300 hours above a depth of 2 fathoms). The data for 1967 are presented in Figure 3.

Discussion

The following conclusions may be drawn from an examination of the data from Cockburn Sound (Table 1 and Figure 1).

(a) The annual curve of inshore water temperatures is very similar to that of air temperatures, with a peak in January or February and a minimum in July or August.

(b) As is to be expected, the range of water temperatures, 8.3 °C, is less than that of air temperatures 12.4°C (monthly mean water temperatures 1960-67, monthly mean air temperatures 1960 and 1967). Air temperatures averaged about 2°C higher for a short period in summer and 2°C lower for as much as six months in winter.

(c) Variation from one year to another is small.

(d) The highest monthly mean water temperature recorded was 24.7°C and the lowest was 14.5°C. Daily sea temperatures show a greater range; the highest temperature was 26.7°C and the lowest was 12.8°C. In every year figures of 25°C or over were recorded and usually occurred in three or four months each summer and in only one year did the figure not fall below 14°C. These then may be regarded as the biological maxima and minima.

(e) Because the figures show considerable consistency it is possible to use meteorological data to estimate water temperatures for periods when no recordings are available. This has proved useful in associating catch rates of juvenile crayfish with temperatures in areas for which no water temperature records were available.

From the water temperature recorded in Gage Roads and off Rottnest Island (Figure 2) the following points may be noted.

* Zoology Department, the University of Western Australia Nedlands.

† Present Address: C.S.I.R.O., Division of Fisheries and Oceanography, Western Australian Marine Research Laboratory. Private Bag, P.O. North Beach, Western Australia, 6020.

TABLE 1

WATER TEMPERATURES IN COCKBURN SOUND IN THE FOREBAY AT BP's (KWINANA) REFINERY

Monthly Means of Daily Maxima and Minima, and Maximum and Minimum Temperatures in Degrees Centigrade

Month	1960	1961	1962	1963	1964	1965	1966	1967	Mean
January	21 4 (20.5–25.6)	24.5 (21.1–25.6)	22 8 (21.1–25.6)	22.7 (20.8–25.6)	23.1 (20.6–25.0)	23 0 (20.6–25.6)	23 3 (21.1–25.6)	22.6 (21.1–25.0)	22.9
February	22 4 (21.6–26 1)	24.7 (22 2–26.1)	23 0 (21 1–25.7)	23.5 (20.0–25.0)	22.6 (19 4–24.4)	22 9 (20 6–25 0)	22 7 (21.1–25.0)	23.8 (22 2–26.1)	23.2
March	21 0 (20 5–25.0)	23.6 (21.6–26.1)	21.7 (20.6–23.9)	23 5 (21.1–26.7)	22.0 (18 3–25 0)	22.3 (20 0–25 0)	22 5 (20 6–24.4)	22 3 (20.0–25 0)	22.4
April	19.5 (18 9–23.9)	20 0 (19 4–22 8)	20 5 (18 9–22 2)	21.0 (17 8–23.9)	19.6 (17.8–21.7)	20 8 (19 4–23 3)	20 1 (17.8–22 8)	20.7 (18 3–23.3)	20.3
May	16.4 (16.1–21.1)	19.0 (17 8–21.1)	19 2 (16 7–21.1)	18 9 (16.7–21.1)	18 0 (15 0–20.0)	18 5 (16 7–21.1)	18 8 (16 7–20 0)	19.0 (16 7–21 7)	18.5
June	15 5 (15 0–18.3)	16 4 (13 9–17.8)	17.5 (16 1–18 9)	15.8 (14 4–17.8)	16 5 (15.0–18.3)	16 8 (14 4–18 3)	16 5 (13 9–18 3)	17.5 (16.1–18.9)	16.6
July	14 5 (13 9–16.7)	15.0 (13 9–16.7)	15.3 (13 9–17.8)	14.9 (13 3–16.1)	14 9 (13 9–16.1)	16 0 (14.4–18.3)	15 1 (13 9–16 7)	15.8 (13.9–17.8)	15.2
August	14.9 (14.4–17.2)	15.5 (13.3–17.2)	16 5 (15 0–17.8)	15 2 (13 3–17.8)	15 1 (12 8–16.1)	15.3 (14.4–17.2)	15 0 (13 3–16 7)	15 6 (14 4–17.8)	15.4
September	16.4 (15.0–20.0)	17.4 (15.0–18.3)	17 1 (15.6–20 0)	16.2 (15.0–17.8)	16.8 (14.4–19.4)	16.6 (14.4–18.3)	16 0 (15 0–17.2)	17.5 (15.6–20.0)	16.8
October	17.8 (15.0–21 1)	18 6 (16.1–21.1)	17.5 (15.0–20.0)	18 5 (16.7–21.1)	17.2 (15.6–20.0)	18 0 (15.6–20.0)	17.0 (13.9–18.9)	19.7 (17.2–22.2)	18.0
November	18 9 (16.6–22.2)	21.2 (18.3–23.9)	20.1 (17.2–23.9)	20 2 (18 3–23.3)	19.1 (15.6–21.7)	19.1 (16.7–22.2)	20.1 (17.2–23.3)	21.1 (18.3–23.3)	20.0
December	22.2 (18.9–25.0)	22.5 (20.0–25.0)	22.0 (18.3–24.4)	22.5 (20.0–25.0)	20.6 (17.8–22.8)	22.8 (20.6–25.6)	21.8 (19.4–23.9)	22.5 (20.0–24.4)	22.1

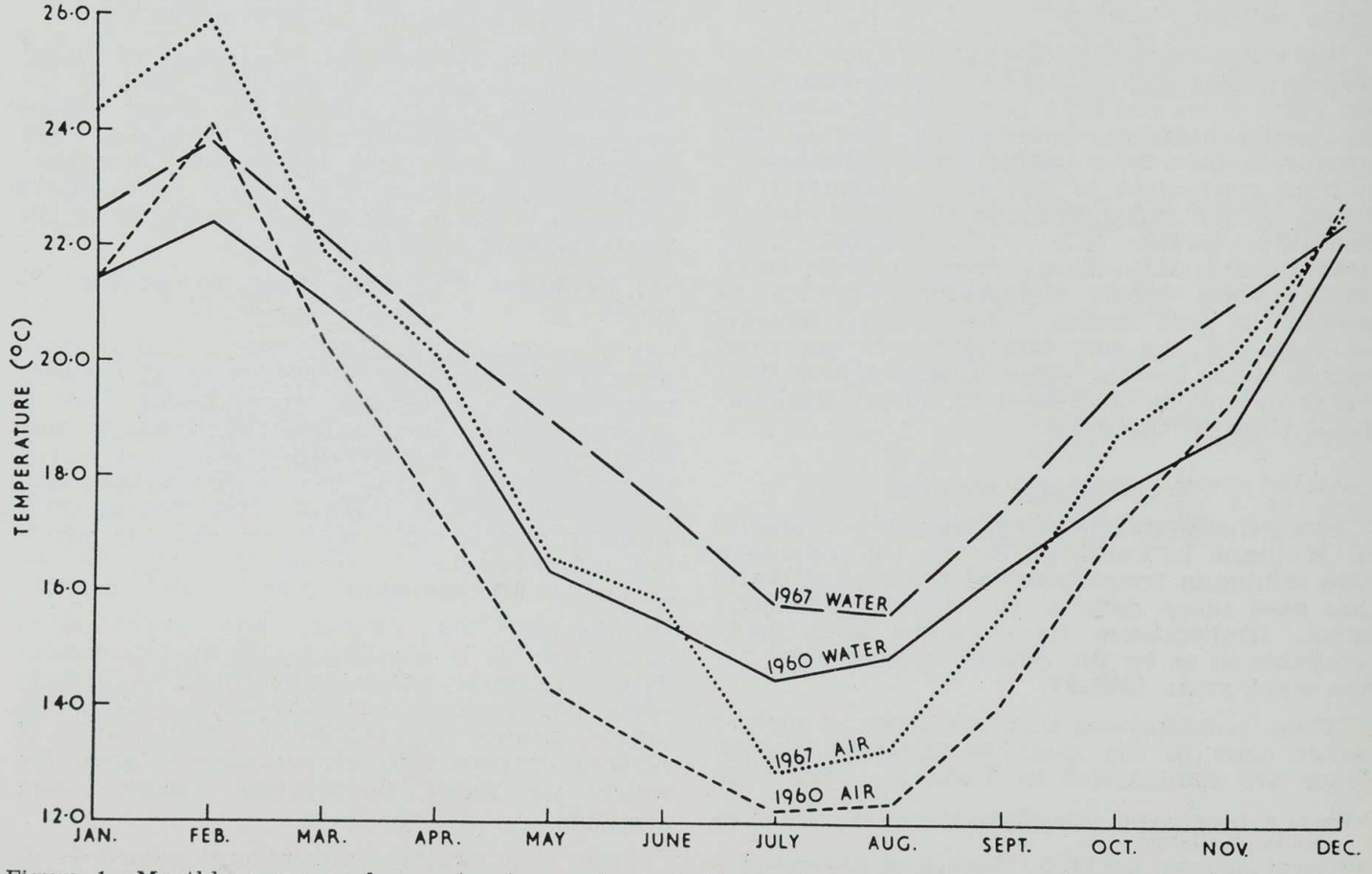

Figure 1.—Monthly mean surface water temperatures in the Forebay, BP's (Kwinana) refinery, Cockburn Sound, (mean of daily minimum and maximum) and monthly mean air temperaure at Perth, Western Australia during 1960 and 1967.

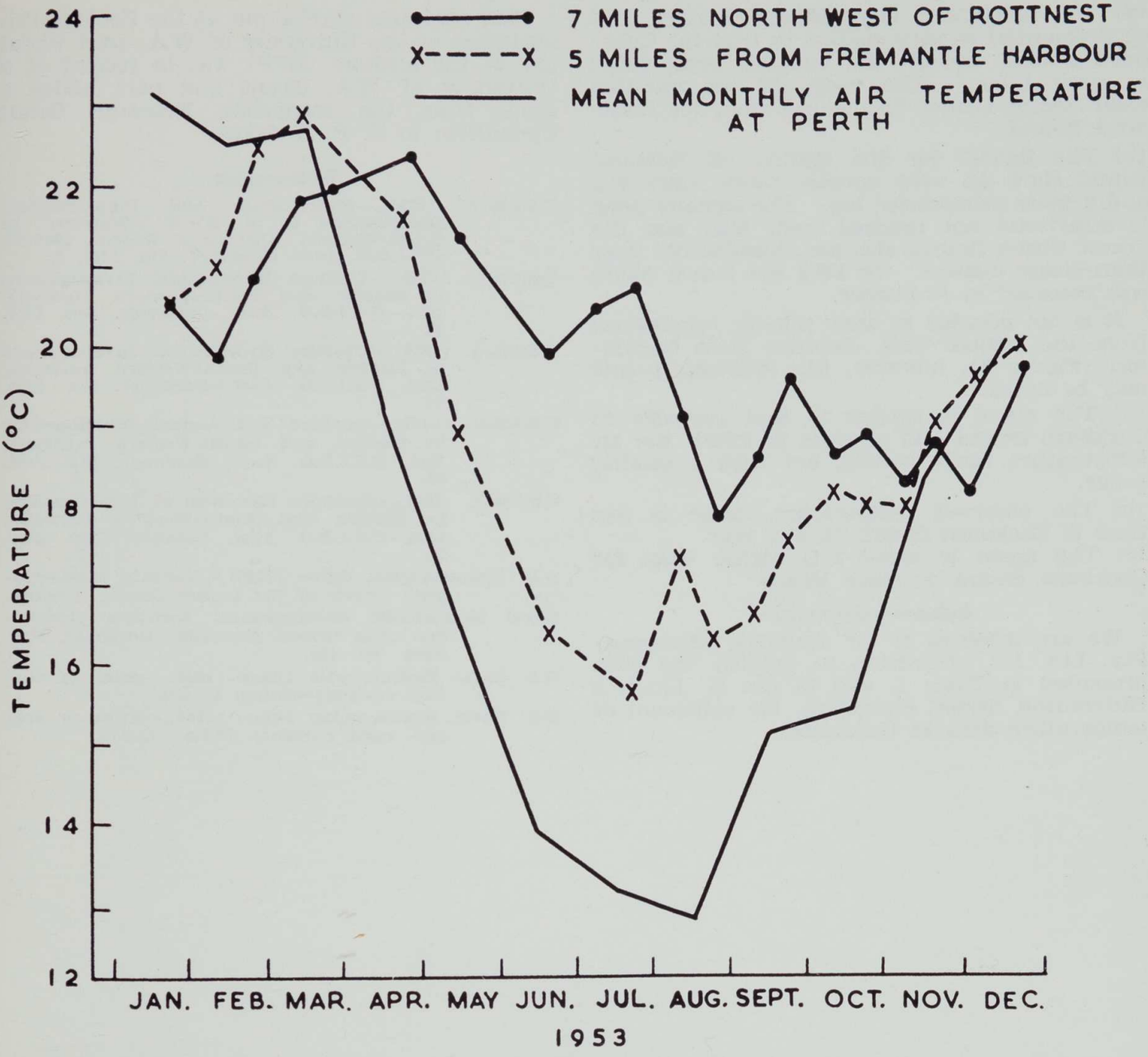

Figure 2.—Surface water temperatures from the "50 Metre Station" 7 miles north west of Bathurst Point, Rottnest Island, and Gage Roads, 5 miles from the entrance to Fremantle Harbour. Monthly mean air temperature at Perth, Western Australia, for the same period.

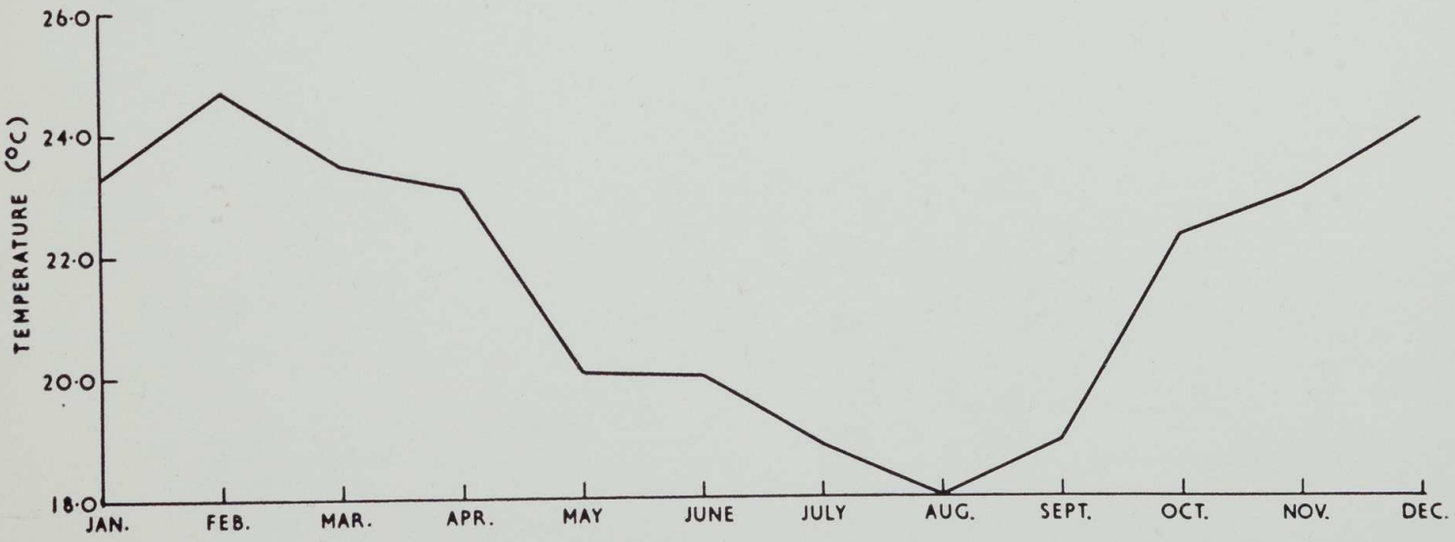

Figure 3.—Monthly mean surface water temperature at Geraldton, Western Australia, during 1967

(a) The curve from Gage Roads (5 miles west of Fremantle) is very similar to that for Cockburn Sound, though the summer peak tends to come later. The range of the monthly mean temperatures, 7°C is less than for Cockburn Sound.

(b) The figures for the station off Rottnest Island show an even smaller range, only 5°C and a more pronounced lag. The summer peak is sometimes not reached until May and the lowest winter figures also are considerably later than closer inshore. In 1952 the lowest figure was recorded in November.

It is not possible to draw reliable conclusions from the limited data recorded from Geraldton (Figure 3), however, the following points may be noted:

(a) The curve is similar to that recorded in Cockburn Sound and appears to follow the air temperature fairly closely, but with a smaller range.

(b) The observed temperature range is less than in Cockburn Sound, in any year.

(c) The mean is about 2°C higher than for Cockburn Sound or Gage Roads.

Acknowledgements

We are indebted to BP Refinery (Kwinana) Pty. Ltd. for permission to publish the data presented in Table 1, and to Mr. E. Jones, 5 Hutchinson Street, Geraldton, for collection of temperature data at Geraldton.

This work was carried out at the Zoology Department of the University of W.A., part whilst one of the authors (BFP) was in receipt of a University of W.A. Grant and part under a grant from the Australian Research Grant Committee to E. P. Hodgkin.

References

C.S.I.R.O. (1951).—Hydrological and Planktological Observations by F. R. V. "Warreen" in South-Western Australian Waters, 1947-50. *C.S.I.R.O. Aust. Oceanogr. Sta. List.* 3.

C.S.I.R.O. (1953).—Onshore Hydrological Investigations in Eastern and South-Western Australia, 1951. *C.S.I.R.O. Aust. Oceanogr. Sta. List.* 14.

C.S.I.R.O. (1954).—Onshore Hydrological Investigations in Eastern and South-Western Australia, 1952. *C.S.I.R.O. Aust. Oceanogr. Sta. List.* 24.

C.S.I.R.O. (1957).—Onshore Hydrological Investigations in Eastern and South-Western Australia, 1955. *C.S.I.R.O. Aust. Oceanogr. Sta. List.* 27.

C.S.I.R.O. (1957).—Onshore Hydrological Investigations in Eastern and South-Western Australia, 1956. *C.S.I.R.O. Aust. Oceanogr. Sta. List.* 30.

G.B. Meteorological Office (1949).—*Monthly Meteorological Charts of the Indian Ocean. London.*

Royal Netherlands Meteorological Institute (1949).—Sea areas around Australia. *Oceanogr. Met. Data.* No. 124.

U.S. Naval Hydrographic Office (1944).—*Atlas of surface currents—Indian Ocean.*

U.S. Naval Hydrographic Office (1944).—*Atlas of seas and swell currents—Indian Ocean.*